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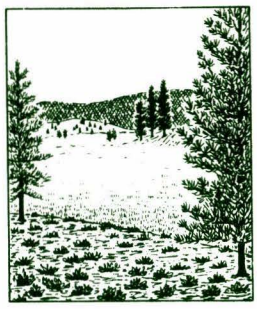

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AIR DRYING OF INCENSE CEDAR: TESTS UNDER SUMMER CONDITIONS IN CALIFORNIA

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INTRODUCTION

Incense-cedar (Libocedrus decurrens) is used extensively in manufacturing slats for wood-cased lead pencils. The pencil slats are manufactured from 3-inch thick planks or flitches that have been dried to a moisture content of 15 to 20 percent.

Air drying of the green planks to a moisture content of about 20 percent is the usual commercial procedure. This practice permits piling the material in any desired location, and eliminates the use of dry kilns. Air drying, however, requires rather large inventories and is influenced by wide variations in drying conditions during the different seasons of the year. Therefore, a study of air drying to determine the effect of piling methods designed to take full advantage of natural drying conditions would be helpful to the industry.

The wood of incense-cedar is not uniform in the physical and chemical properties that control rate of drying. Green sapwood has a high moisture content, sometimes exceeding 250 percent of oven-dry weight, but its structure permits rapid diffusion of the moisture. "Light" heartwood, generally occurring in the center and the upper parts of the tree, has a comparatively low moisture content, sometimes just above the fiber saturation point. The "heavy" heartwood, generally occurring near the transition zone between sapwood and heartwood, and chiefly in the lower parts of the tree, has a high moisture content, approaching that of the sapwood. Heavy heartwood also contains within the cells a high amount of extractives that have a marked retarding effect on the movement of water through the wood.

Because of these properties and the relatively large dimensions of the material, considerable care must be exercised on the air-drying yard and in the kiln to insure rapid drying without objectionable drying defects.

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The California Forest and Range Experiment Station, Berkeley, and The California Cedar Products Company, Stockton, have completed the first phase of a cooperative study of the air drying of 3-inch thick incense-cedar planks and squares at the sawmill of Calmills, Inc., Pioneer Station, Amador County, California, during the summer of 1955.

PURPOSE OF THE EXPERIMENT

The object of the experiment was to answer the following questions:

1. What are the drying rates of the sapwood, the light heartwood, and the heavy heartwood, and what is the air-drying time for each type to reach a moisture content of 15 percent?
2. What is the drying rate of the planks and of the squares?
3. How do pile spacing and position in the pile affect the drying rate?
4. What is the incidence of drying defects in the planks and in the squares?
5. How do pile spacing and position in the pile affect the incidence of defects?
6. Under the prevailing summer weather conditions, can such material be dried without serious defects, specifically checks?

EXPERIMENTAL PROCEDURE

To learn the answers to these questions the experiment was set up as follows:

Test Material

The test material was all 3 inches thick and 16 feet long. The planks and flitches were random width from 7 to 18 inches. The squares were sawn by spacing the edger saws close together; their minimum spacing was only 4 inches so that the "squares" were actually 3 x 4 inches in cross section. The random-width planks and the squares were piled separately in units 44 inches wide, 44 inches high and 16 feet long, using three stickers per course. The stickers were sawed a nominal 1 x $1\frac{1}{2}$ x 44 inches. Nine test units of planks and nine of squares were piled in this manner.

Pile Foundation

A continuous pile foundation 108 feet long was built (fig.1). It consisted of two rows of 3-inch thick, random-width cedar mud-sills and 6 x 8-inch posts each supporting a 6 x 8-inch stringer. The total height of the foundation was 24 inches above the ground. The stringers were spaced 9 feet 10 inches on center to accommodate a forklift truck.

Figure 1.--Spacing of piles on continuous foundation for air drying.

Pile Spacing

Three pile spacings were marked on this common pile foundation:

1. No spacing (actually the piles were placed as closely together as was practical with a forklift truck and were usually spaced 4 to 6 inches apart).

2. A pile spacing of 2 feet.

3. A spacing of 6 feet.

The test units, separated by 5-inch square bolsters, were piled three high. One test pile of planks and one test pile of squares were used in each of these three spacings.

To isolate the test piles in carrying out the pile spacing, 10 additional similar piles of mill-run planks were used (fig.1).

Samples

In order to study the drying rate of the test material, representative pieces were selected from planks and squares as they were piled into units. From these selected pieces, samples were cut 1 meter long, end-coated, and weighed immediately on scales accurate to 0.5 gram.

Samples were selected to represent: heavy heartwood (sinker stock), light heartwood, and sapwood. During the preparation of these samples we observed less than the expected differences in weight between heavy heartwood and light heartwood. Some of the samples of heavy heartwood did not seem to represent extremes of this type. Six sample planks of heavy heartwood, six of light heartwood, and two of sapwood were prepared. Similarly, 42 sample squares, totalling about the same volume as the sample planks, were prepared. These were arranged in 14 sample groups. Each group consisted of three squares of a single type of wood, which could be placed in the piles together and weighed as a group.

The samples were placed between the 3 units of each test pile. "Top" samples were therefore located at two-thirds the height of the pile and "bottom" samples at one-third the height of the pile. The 5- by 5-inch bolsters were spaced to accommodate the 1-meter-long samples and prevent excessive air movement around the ends. The bolsters provided a 1-inch sticker space above and below the samples. Thus the samples were exposed to the same drying conditions as all lumber on the yard.

Weather Records

Air temperature and relative humidity were recorded by a hygrothermograph during the drying period. Hourly temperature and relative humidity readings from these records were averaged for each day. Seven-day moving averages of these daily values were computed. These temperatures and corresponding equilibrium moisture content values were plotted (fig.2).

Moisture Content of Samples

The 28 samples of planks and squares were weighed when they were prepared and placed in the test piles and again at regular intervals during the air drying. The weights were plotted as an indication of the drying rate. Current moisture content of the samples was also determined by a moisture meter of the resistance type with electrodes 5/16-inch long and a range of 7 to 60 percent.

After 15 weeks on the yard, the weights and the moisture meter readings indicated that the samples were thoroughly air-dried. All samples were again weighed, and the oven-dry weights were determined from two 1-inch sections cut from each piece, one near the center, and one 12 inches from one end. The moisture content of each sample at each time of weighing during the air drying was then calculated. The drying curve for each sample was plotted.

Drying Defects

The samples were inspected periodically for drying defects. Surface checks were the principal defect found.

The full-length test material itself was examined to measure the number and length of checks. For this purpose, all 18 units of test material were removed to a planing mill. From each unit, representative pieces were selected as follows: from the top units of each pile, all pieces in the two top and the two middle courses; from the middle units of each pile, the same (all pieces in the two top and the two middle courses); and from the units at the bottom of each pile, all pieces in the two top, the two middle, and the two bottom courses. These representative pieces were planed on both faces to a thickness of 2 13/16 inches, care being taken to remove a uniform 1/16 inch of wood from the sap face. This sap or bark face is more susceptible to checking than the opposite face.

The sap side of every piece was inspected in two selected areas, each 1 foot long and as wide as the piece. One area was at the left of middle and the other was between 1 and 2 feet from the right end. Thus the areas inspected were proportional to the width.

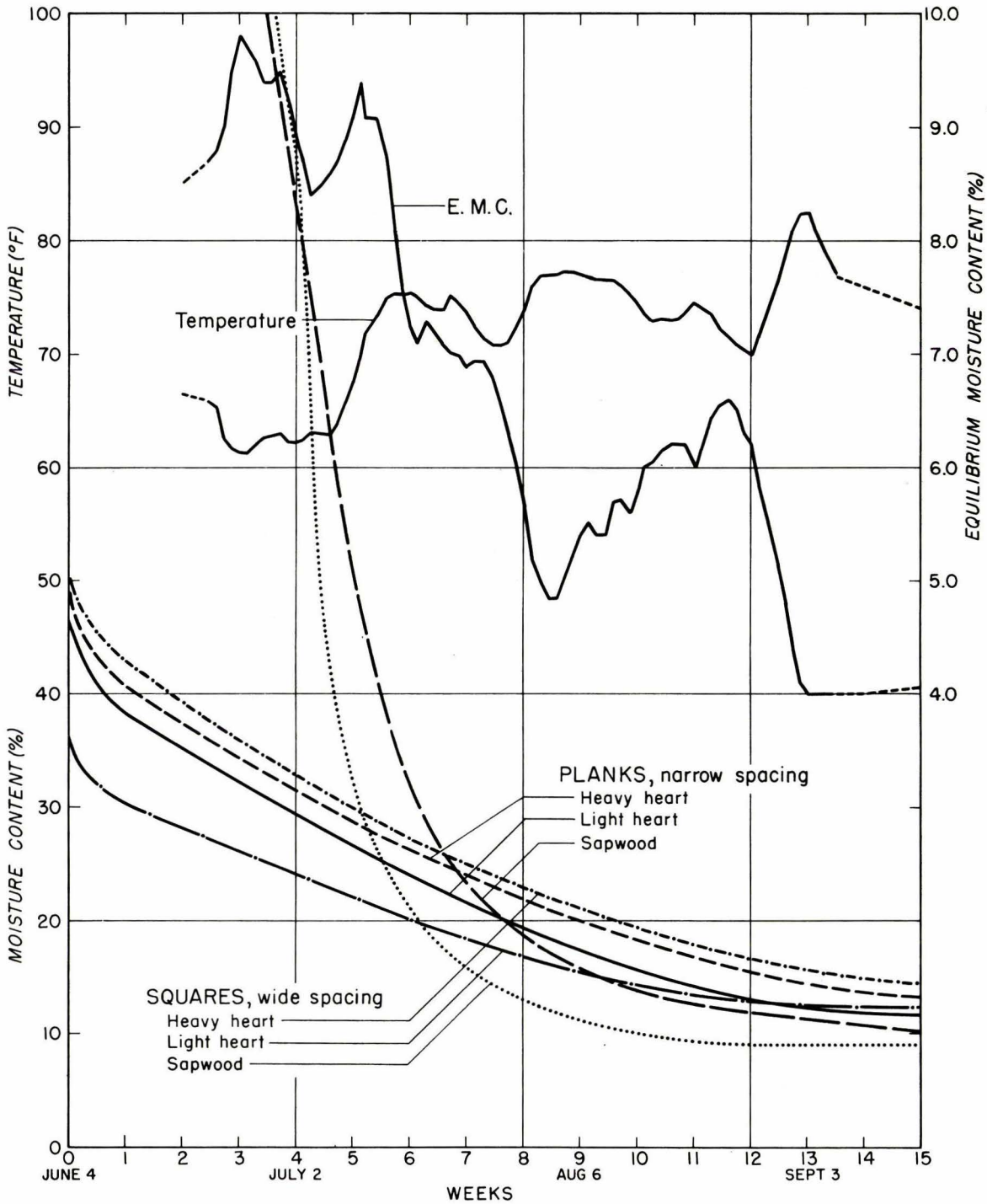

Figure 2.--Average air temperature and equilibrium moisture content, and drying curves for cedar planks and squares during air drying.

RESULTS

Rate of Drying

Weather conditions on the yard were conducive to very fast drying. Maximum daytime temperatures were often above 100° F, and relative humidity below 10 percent.

All samples showed a sharp loss in weight during the first week on the yard. During the next 10 or 11 weeks, all heartwood samples, both planks and squares, showed a slower but steady loss in weight. After about 12 weeks of drying, the light heartwood samples, especially the squares, showed a much slower loss of weight, indicating they were approaching equilibrium. The heavy heartwood samples, especially the planks, continued losing weight slowly until the end of the 15-week drying period (fig.2).

Sapwood samples, both planks and squares, lost weight very rapidly, reaching a moisture content of 20 percent in less than 8 weeks. Sapwood squares showed very little weight loss after 10 weeks, indicating they had reached equilibrium. The combined effect of pile spacing and width of material on drying rate is shown, to a degree, in the drying of sapwood planks (wide spacing) and sapwood squares (narrow spacing). The planks dried from a green moisture content of 199 percent to 20 percent in $7\frac{1}{2}$ weeks, while the sapwood squares dried from a green moisture content of 259 percent to 20 percent in only $6\frac{1}{4}$ weeks. The maximum rate of drying appeared to be 55 percent in 1 week, or almost 8 percent per day.

Heavy heartwood planks with narrow spacing and light heartwood squares with wide spacing would normally be expected to show the greatest difference in rate of drying. This was not always so. Heavy heartwood planks and squares dried at almost the same rate. Light heartwood planks in piles with narrow spacing actually dried somewhat faster than light heartwood squares in piles with 6-feet spacing, but they started with a green moisture content 10 percent higher than the light heartwood squares. Drying conditions were so favorable for fast drying that all planks and squares dried to virtually the same final moisture content in 15 weeks regardless of pile spacing or position in the pile (table 1).

All material except the heartwood planks dried uniformly. To determine moisture distribution in the samples, their average moisture content was determined by the oven-scale method, a standard method in the lumber industry, and their moisture content at mid-thickness was determined with an electric moisture meter having insulated electrodes $1\frac{1}{2}$ inches long. For the squares, both determinations agreed closely, indicating thoroughly dry material (table 2). Sapwood planks also were uniformly dry although they showed a slight moisture pick-up at

the surface. Heartwood planks, however, showed higher moisture readings at mid-thickness, indicating that the centers were not completely dry.

Table 1.--Final moisture content of squares and planks (average of both light heart and heavy heart), by pile spacing and position in the pile, oven-scale method

Type of material and position in pile	Moisture content when spacing of piles was--		
	0 feet	2 feet	6 feet
	Percent		
SQUARES:			
Top	15.6	10.4	14.6
Bottom	12.2	15.8	14.5
PLANKS:			
Top	15.1	13.2	13.2
Bottom	12.5	14.4	14.1

Table 2.--Average moisture content of squares and planks, by oven-scale and moisture-meter methods

Type of material and test method	Sapwood	Light heartwood	Heavy heartwood
	Percent		
SQUARES			
Oven-scale	9.2	12.2	13.8
Moisture-meter	9.6	12.8	13.9
PLANKS			
Oven-scale	10.3	12.3	15.2
Moisture-meter	9.0	15.2	17.8

In the heartwood planks, moisture distribution improved as the stock became drier. This was shown by a more detailed analysis of 12 planks; eight of these had mid-thickness moisture contents of 15 percent and higher, four of less than 15 percent. Average moisture contents for these two groups were as follows:

Moisture content at mid-thickness:	Moisture meter	Oven scale
15 percent or higher	18.3%	14.4%
Less than 15 percent	12.9%	12.4%

Number and Length of Checks

Checks were fewer and shorter in squares than in planks. They were also fewer and shorter in narrow planks than in wide planks (table 3). The number and length of checks in planks was not influenced appreciably by differences in the piling (table 4). The number and length of checks in squares, however, were appreciably less at the 0 spacing than at 2- and 6-foot spacing, and appreciably greater at the top of the pile than at the middle and bottom.

Table 3.--Number and length of checks in 3-inch incense-cedar, by width of test material (per thousand square feet of surface)

Width of material (inches)	Number		Length in inches	
	Total	Ratio comparative value	Total	Ratio comparative value
Squares:				
4	371	1	1,097	1
Planks:				
7-10	1,130	3.4	5,220	4.8
11-14	1,420	3.8	6,000	5.5
15-18	2,020	5.4	7,550	6.9
All planks	1,400	3.8	5,940	5.4

Table 4.--Checking in 3-inch thick incense-cedar, by piling method (per thousand square feet of surface)

Piling variable	Checks in squares		Checks in planks	
	Number	Total length in inches	Number	Total length in inches
Pile spacing:				
0 spacing	256	598	1,190	5,180
2 ft. spacing	518	1,553	1,530	7,200
6 ft. spacing	341	1,146	1,460	5,400
Position in the pile:				
Top	406	1,718	1,380	5,800
Middle	311	820	1,377	6,030
Bottom	349	877	1,430	5,960

CONCLUSIONS

1. Air drying on the yard at Pioneer Station, Amador County, California (elevation 3,000 feet) during the summer of 1955 (15 weeks from June 4 to September 17) was conducive to very fast drying. Incense-cedar lumber dried to less than 15 percent moisture content in 8 to 15 weeks. High-moisture-content sapwood dried in 8 weeks, light heartwood in 10 weeks, and heavy heartwood in 15 weeks.

2. Width of material showed no appreciable effect on drying rate.

3. Pile spacing and position in the pile showed no appreciable effect on drying rate.

4. Width of material had a significant effect on the incidence of checks. The number of checks in the planks was almost four times the number in the squares. The total length of such checks in the planks was more than five times the length in the squares. The widest planks showed an even greater ratio of checks. The greatest ratio of checks in planks compared to squares was almost 7 to 1. Thus, the incidence of checks increased as the width of the material increased.

5. Pile spacing and position in the pile had little effect on the incidence of checks in the planks. The narrow pile spacing, however, appears to lessen the incidence of checks in squares and the top position in the pile appears to increase it.

The danger of checking has been considered an important reason for close spacing of the piles on commercial yards. This experiment, however, indicates that plank width is the more important factor.

6. Under the conditions of the experiment, incense-cedar planks and squares, especially wide planks, cannot be dried without serious checking.

A similar air-drying study during less favorable drying weather (late autumn and winter) would be desirable to determine the effect of pile spacing and position in the pile on rate of drying and the occurrence of checks.

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